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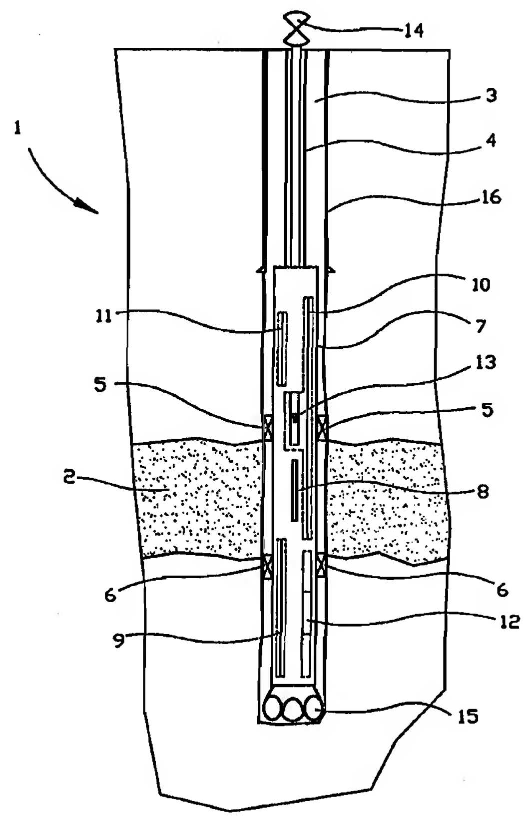
(54) Title: A METHOD FOR USE IN SAMPLING AND/OR MEASURING IN RESERVOIR FLUID

(57) Abstract

The invention relates to a method for use in sampling and/or flow measuring, quantity gauging, possibly other analysis, in reservoir fluid that one comes across in a ground formation (1), e.g. during drilling of an exploration well (3) for hydrocarbons. Inter alia, an object of the invention is that the sampling, flow measuring and quantity gauging or the remaining analyses shall be carried out in reservoir fluid positioned down into the hydorcarbon carrying layer (2), the same being maximum stabilized and with a content of drill fluid not worth mentioning after the drilling. This is realized in such a way that the well (3) is sealed in an area at the hydrocarbon carrying layer (2) by means of seals (5, 6); that reservoir fluid from said layer (2) is supplied in a drill string (4) used during drilling and passed through the sealed area of the well (3); that the sampling an the respective measurements or analyses are carried out within the sealed area of the well (3) while the reservoir fluid flows controllably into the drill string (4), and that reservoir fluid is returned from the drill string (4) to the hydrocarbon carrying layer (2) after completed sampling and respective measuring or analysis. The sampling and the respective measurements and analysis are made by means of accessories (9, 10, 11, 12) disposed in a housing member (7) on the drill string (4).



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A METHOD FOR USE IN SAMPLING AND/OR MEASURING IN RESERVOIR FLUID

The invention relates to a method adjusted for use when taking samples and/or making flow measurements and quantity gauging, possibly other analysis, in reservoir fluid run into within a ground formation, e.g. when drilling an exploration well for hydrocarbons.

Use of new technology in i.a. drilling and production in ground formations exhibiting high pressure and temperature, injection of water and gas for increasing the degree of extraction, multiphase production on the seabed and transport of produced hydrocarbons in pipelines on the seabed, makes constantly higher demands on maximum knowledge about the physical and chemical properties of the gas, oil and water to be produced from the deposit. Previously, such knowledge about the reservoir fluid within the ground formation was normally provided by means of testing at complete production. However, today there is a clear tendency towards increased use of various sampling tools which, during drilling, are passed down into and pulled up from the well by means of a

wire string. The last mentioned method, however, gives fewer possibilities to provide data about relevant parameters of the reservoir fluid than what is possible at full production testing.

Each of the above-mentioned methods has its different advantages and weaknesses. The strength of full production testing is that data can be collected in a large volume of the reservoir fluid, so that the data become very reliable. The main weakness is the large expenses incurred upon e.g. renting a rig and other necessary accessories. Another significant deficiency is that it becomes necessary with one or another form of handling of the large amount of reservoir fluid conducted up to the surface. Today, this takes normally place through burning of the oil and gas, a very environmental hostility. The oil companies have, therefore, as a goal that such burning shall cease subsequently to the year 2003. Important advantages of use of sampling and measuring accessories lowered down into the well by mans of a wire string, is that samples of the reservoir fluid can be taken continuously during the drilling, and that this can take place with far less expenses than upon full production testing. Nor is it necessary to burn oil and gas. The main weakness of the accessory is, as already mentioned, the limitations in what the accessory can provide of data about relevant parameters for the reservoir fluid. E.g., absolutely necessary data about the flowing conditions in the reservoir fluid can not be provided. Nor is the accessory usable in connection with saturated gas reservoir as pressure and temperature can not be stabilized. The weakness is increased further due to the fact that very small amounts of the reservoir fluid are taken out, and that the accessory has to be handled from the surface. Moreover, the last mentioned

condition may result in that the measuring results for the reservoir fluid become unreliable. Such errors in the measuring results may i.a. be due to the fact that the accessory is not brought into the correct position within the reservoir during the sampling; that the reservoir fluid where samples are taken is contaminated with drilling fluid supplied during the drilling, and that sand accompanying the reservoir fluid during the sampling gives leakiness and leakage in the accessory.

The main object of the present invention is to provide a method adapted for use in sampling and/or flowing measuring, quantity gauging, possibly other analysis, in reservoir fluid that one comes across in a ground formation, e.g. during drilling of an exploration well for hydrocarbons, where the above-mentioned deficiencies and disadvantages substantially are overcome. This is, as it appears from the characterizing clause of the present independent claim, realized in such a way that the well is sealed in an area at the ground formation's hydrocarbon carrying layer, that the reservoir fluid from said hydrocarbon carrying layer is supplied into a pipe string, e.g. the drill string used during the drilling and which, preferably, at least is passed through the sealed area of the well; that said sampling and/or flow measuring, quantity gauging, possibly other analysis, are carried out in the sealed area of the well while the reservoir fluid flows controllably into the pipe string, and that the reservoir fluid is returned from the pipe string to the hydrocarbon carrying layer within the ground formation subsequently to terminated sampling, and/or flow measuring, quantity gauging, possibly other analysis in the reservoir fluid. Other advantageous features of the invention appear from the dependent claims and, moreover, the description. Thus, the

sampling, the flow measurements and the quantity gauging or the other analyses can be carried out in reservoir fluid positioned down within the hydrocarbon carrying layer, in reservoir fluid stabilized as much as possible and, moreover, free of drill fluid after drilling, and which can be recognized by means of a downhole measuring instrument/ detector, and which signalizes when drill fluid is out, and sampling, measurements or analyses can start, so that the data about relevant parameters for the reservoir fluid become very reliable. This is due to the fact that a larger amount of the reservoir fluid, prior to sampling and measurements, has been passed out from the hydrocarbon carrying layer. The supply of reservoir fluid is controlled by means of e.g. a downhole valve or a surface valve, a so-called choke. A piston separates the reservoir fluid from water or N_2 where said water or N_2 is used to force out mud/drill fluid from the drill string, possibly the production string, and out into the surrounding annulus formed between the pipe string and the well wall.

Subsequent to perforation, as known per se, the piston will move upwardly when reservoir fluid is let in with a speed adjusted by means of a valve/choke. Thus, the inflow of reservoir fluid can be measured by reading the amount of liquid (water or N_2) which, during the inflow, has flowed into a tank at the surface. When the reservoir fluid has risen so high up in the string that the liquid has reached the security valve, often called the BOP, at the seabed or the surface, the piston is stopped in a seat. Then, all tests are carried out downhole, and the reservoir fluid is pressed back to the reservoir.

Uniform pressure data are achieved due to stabilized inflow speed in the pipe string. Further, that the sampling, the flow measurements and quantity gauging or the other analyses can be made by means of accessory which, at any time, is available, so that as many data as possible about relevant parameters for the reservoir fluid can be provided; that it is possible, by means of trace elements (tracers), to carry into effect safe flow measurements within the reservoir fluid supplied into the pipe string, and that the reservoir fluid can be returned from the pipe string to the ground formation after the sampling, flow measurements and quantity gauging or the other analyses have been completed.

In reference to the attached figure, a further account has been given of a preferred exemplary embodiment, wherein:

The figure shows a diagrammatic detail section within a lower portion of an exploration well which is in the course of being drilled in a ground formation. The well is drilled by means of drilling accessory comprising a bit assigned a drill string; the sampling, flow measuring and quantity gauging or the other analyses of the reservoir fluid being carried out by means of accessory positioned within an assigned housing member surrounding the drill string above the bit. The well is sealed in an area at the hydrocarbon carrying layer of the ground formation by means of seals disposed externally on the housing part, and which are expanded for resting sealingly against the well wall. Some portions of the housing part have been left out, so that some constituents of the accessory for sampling, flow measurements and quantity gauging or other analyses can be indicated sketch-like in the figure.

In the exemplary embodiment of the invention, the present invention has been adjusted for use upon sampling, flow measurements and quantity gauging, possibly other analysis, in reservoir fluid come across in a ground formation 1 during drilling of an exploration well 3 for hydrocarbons but, of course, this does not prevent the present invention from being used in another connection, e.g. in a ground formation already put into full production. The goal is, as mentioned above, i.a. that typical properties or parameters of the reservoir fluid that one comes upon in the ground formation 1, should be fixable with the highest degree of accuracy, without having to bring a large amount of hydrocarbons out from the well 3 and up to the surface. According to the invention, this is achieved in such a way that the well 3 is sealed in an area at the hydrocarbon carrying layer 2 of the ground formation 1. Thereupon, reservoir fluid from the hydrocarbon carrying layer 2 is supplied in a drill string 4 which, at least, has been passed through the sealed area of the well. The sampling , the flow measurements and quantity gauging and the other analyses of the reservoir fluid are carried out in the sealed area of the well 3. Preferably, this takes place after the drill string 4 is sealed and filled with reservoir fluid supplied thereto. Thus, the sampling and the respective measurements or analyses take place after a larger amount of the reservoir fluid has been supplied into the drill string 4. This involves the possibility of taking samples or making measurements in reservoir fluid stabilized after the drilling, and which substantially is lacking a drill fluid content. Inter alia, this is a result of the fact that the previously mentioned piston separates the reservoir fluid from the above positioned water or N_2, and where said water or N_2 is used to press out mud/drilling mud from the drill string/production

tubing string and out into annulus. After perforation, the piston will move upwardly within the string when reservoir fluid is let into the same. After sampling and the respective measurements are completed by means of sampling, measuring or analyzing accessories 9-12 which are lowered down into the well 3 together with the drill string 4, the reservoir fluid is being returned from the drill string 4 to the hydrocarbon carrying layer 2 in the ground formation 1 in a suitable way. Thereupon, the sampling, measuring or analyzing accessories 9-12 are pulled out from the well 3 together with the drill string 4, so that the restricted amount of reservoir fluid accompanying the equipment up to the surface may be further appraised in the laboratory. Thus, one avoids that a large amount of reservoir fluid has to be passed to the surface. For the sake of good order, it is mentioned that the well 3 first is sealed subsequent to the drilling being ceased after having passed the respective hydrocarbon carrying layer 2 in the ground formation 1. Possibly, the drilling may be continued downwardly towards the underlying layer, so that samples can be taken and measurements or analyses may be made therein in a corresponding way.

First, prior to the sampling, flow measurements and quantity gauging or the other analyses, it will normally be carried out a logging and washout of the well 3 before the same is sealed. The washout can be made by means of a washing agent which is circulated within the well 3. When, thereupon, reservoir fluid is supplied into the drill string 4, the drill fluid is circulated through a suitable valve between the drill string 4 and the annulus formed between the well wall and the drill string 4, and drill fluid is transferred further from the annulus for storage in tanks, not shown, or similar at the surface. Thus, drill fluid is replaced by

gas/liquid (N_2/water) known and prepared for the testing phase by means of trace element added. Above, it is mentioned that the sampling, flow measurements and quantity gauging or the other analyses in the reservoir fluid are carried out continuously, and after the drill string in a controlled way has been filled with reservoir fluid by means of a downhole valve. However, this does not prevent that the sampling, flow measurements and quantity gauging or the other analyses can take place at another expedient point of time. E.g., this may be the case where it is desirable to make continuous measurements while the reservoir fluid is being supplied into the drill string 4.

Further, in the figure set, an exploration well 3 has been shown, drilled as known by means of a bit 15 with a drill string 4 assigned thereto and which, during drilling, is pressure equalized by means of drill fluid with tracer added thereto. The drill string 4 may e.g. be a coiled tubing, etc. Above the bit 15, the drill string 4 is surrounded by an assigned housing member 7 having a length preferably somewhat larger than the height of the hydrocarbon carrying layer 2 of the ground formation. The housing member 7 may be made of steel having a high durability against influence from an environment which is acid and has a high content of chlorides. Respective end of the housing member 7 is coupled to the drill string 4, possibly the bit 15, in a pressure-tight way. Moreover, the well 3 may be equipped with a casing 16 which either is terminated above the hydrocarbon carrying layer 2 or passed through the same. In the latter case the casing must be equipped with e.g. perforations at said layer 2.

The housing member 7 is equipped with expandable seals 5, 6 spaced from each other and externally on the housing member 7, so that the well 3 can be sealed. Respective seal/packer 5, 6 is placed at upper and lower side of the hydrocarbon carrying layer 2. Of course, it is possible with a different positioning of the seals 5, 6 than as shown, e.g. merely at a central portion of said layer 2. The seals 5, 6 may be of any suitable type. It shall be mentioned that the housing 7 is centralized within the well 3 when the seals 5, 6 are expanded to rest sealingly against the well wall. The length of the housing member 7 and the positioning of the seals 5, 6 are determined on the basis of preceding seismic investigations in the ground formation 1. Moreover, the housing member 7 is equipped with at least one openable gate 8 or the like, so that the reservoir fluid can be supplied into or returned from, respectively, the drill string 4, through the housing member 7.

Within the housing member 7, the drill string 4 is equipped with a suitable valve arrangement 13 which is such adapted that the reservoir fluid can pass into or out of the drill 4 string during the supply from or the return into the ground formation 1, respectively. Further, the upper end of the drill string 4 is assigned a further valve arrangement 14 which is such adapted that the drill fluid may pass out from or into the drill string in dependency of whether the reservoir fluid is supplied into or returned from the same, such as previously described. The drill fluid is stored in e.g. tanks, not shown, when reservoir fluid occupies the drill string 4. Moreover, the last mentioned valve arrangement 14 is such adapted that the drill string 4 may be closed when the reservoir fluid supplied has reached up to the upper valve arrangement 14 (e.g. a BOP) or any other

desired level in the drill string 4 in that a liquid separating piston, not shown, is stopped in a seat.

Further, the housing 7 is assigned the accessory required for taking the samples and making the measurements necessary for charting relevant properties or parameters of the reservoir fluid. Said accessories for sampling and measuring are selected among the accessories which, at any time, are available on the market. It is clear that the housing member 7 may be equipped with other accessories for sampling and measuring than those described in the continuation. The sampling may e.g. be carried out by means of single-phase containers 9 for oil, gas and water. Measuring of e.g. temperature, pressure, content of H_2SO and SO_4, pH-conductivity, density, and Cl-value, etc., can be made by means of a sensor-pipe string system 10. PVT-values (pressure, volume, temperature), IR (infrared radiation) can be measured by means of an acoustic resonance spectrocopy sensor system 11 (Acoustic Resonance Spectrocopy Sensor system). In order to measure flow within the reservoir fluid, the housing member has accessory 12 for adding a suitable tracer for oil, gas and water into the reservoir fluid, and said trace element can be added into the reservoir fluid. The adding takes, preferably, place during the filling of the drill string 4 and until it has been filled with reservoir fluid and closed by means of the upper valve arrangement 14. Besides, the housing member 7 is equipped with an acoustic communication system, not shown, so that a higher number of sensor systems for various types of measurements can be placed within the housing member 7 in desired combinations. Said communication system consists of smaller and intelligent communication units coupled to the various sensors within the housing member 7. Thus, measuring results from respective

sensor may be transmitted acoustically to a non-shown logging or telemetry unit on the surface, without the use of communication cable. This is favourable because transfer of signals by cable, due to the complexity of the sensors or movable parts in the tool, normally is very problematic in tools having a small diameter. After completed sampling and measurements in the reservoir fluid, and the reservoir fluid returned from the drill string 4 to the ground formation 1, the housing member 7 with the accessories 9-12 assigned thereto, pulled up to the surface together with the drilling equipment. Whereupon the equipment concerned is disconnected from the housing member 7 og brought to the laboratory, so that the reservoir fluid can be analyzed further.

In describing the exemplary embodiment, it is stated that the reservoir fluid is supplied into and returned from the drill string 4. However, cases may exist in which the present invention is utilized in such a connection that the pipe string in lieu e.g. is a tubing string or an assigned testing pipe string extending along the drill string 4 and, preferably, between the bit 15 and the valve arrangement 14 at the surface. Further, cases are thinkable in which it is more suitable that the housing member 7, in lieu of the shown positioning down at the bit 15, is disposed farther up on the pipe string. Likewise, that more than the one shown of housing member 7 can be disposed, each having its assigned accessories for sampling and measurements, so that simultaneously samples may be taken and measurements made from various layers in the ground formation 1.

C l a i m s

1. A method adapted for use in sampling and/or flow measuring, quantity gauging, possibly other analysis, in reservoir fluid that one comes across in a ground formation (1), e.g. during drilling of an exploration well (3) for hydrocarbons, c h a r a c t e r i z e d i n that the well (3) is sealed in an area at the hydrocarbon carrying layer (2) of the ground formation (1); that reservoir fluid from said hydrocarbon carrying layer (2) is supplied into a pipe string (4), e.g. a drill string used during drilling, preferably passed at least through the sealed area of the well (3); that said sampling and/or flow measuring, quantity gauging, possibly other analysis, is carried out in the sealed area of the well (3) while the reservoir fluid is flowing controllably into the pipe string (4), and that the reservoir fluid is returned from the pipe string (4) to the hydrocarbon carrying layer (2) in the ground (1) formation after completed sampling and/or flow measuring, quantity gauging, possibly other analysis, in the reservoir fluid.

2. A method as claimed in claim 1, c h a r a c t e r i z e d i n that the well (3) is sealed by means of at least two seals/packer elements (5, 6) spaced from each other and disposed externally on a housing member (7) assigned to the pipe string (4) at the hydrocarbon carrying layer (2).

3. A method as claimed in claim 2, c h a r a c t e r i z e d i n that the reservoir

fluid is supplied into the drill string (4) through at least one gate (8) or the like, formed in the housing member (7).

4. A method as claimed in any one of the preceding claims, characterized in that said sampling and/or flow measuring, quantity gauging, possibly other analysis, in the reservoir fluid are carried out by means of sampling, flow measuring and quantity gauging accessories, possibly other analyzing accessories (9, 10, 11) disposed within the housing member (7).

5. A method as claimed in claim 4, characterized in that the sampling is made by means of e.g. single-phase containers (9) for reservoir fluid.

6. A method as claimed in claim 4, characterized in that the respective measurements, possibly analyses, in the reservoir fluid are made by means of e.g. sensor systems (10, 11).

7. A method as claimed in any one of the preceding claims, characterized in that the pipe string (4) is sealed when it is filled with reservoir fluid.

8. A method as claimed in claim 7, characterized in that the pipe string (4) is closed by means of a valve arrangement (14) which, preferably, is disposed at the upper end of the pipe string (4).

9. A method as claimed in any one of the preceding claims, c h a r a c t e r i z e d i n that trace elements (tracers) are added into the reservoir fluid supplied into the pipe string (4).

10. A method as claimed in claim 9, c h a r a c t e r i z e d i n that said trace elements are added by means of admixing accessory (12) disposed in the housing member (7).

11. A method as claimed in any one of the preceding claims, c h a r a c t e r i z e d i n that respective measure or analysis result from the sensors (9, 10) are converted and transmitted to the surface by means of an acoustic communication system disposed within the housing member (7).

12. A method as claimed in any one of the preceding claims, c h a r a c t e r i z e d i n that a piston/plug separates the reservoir fluid from water or N_2, said water or N_2 being used to press out mud/ drilling fluid from the drill string/tubing string (4) and out into the outwardly positioned annulus between the pipe string (4) and the well wall and/or casing (16), whereupon an opening is made for inflow of reservoir fluid, so that the piston is displaced within the string (4) until it stops in a seat preferably placed at an upper security valve, whereupon the reservoir fluid by means of the piston and rearwardly positioned water or N_2 is returned/pressed from the pipe string (4) to the hydrocarbon carrying layer (2) in the ground formation (1) after samples and/or measurements have been carried out.

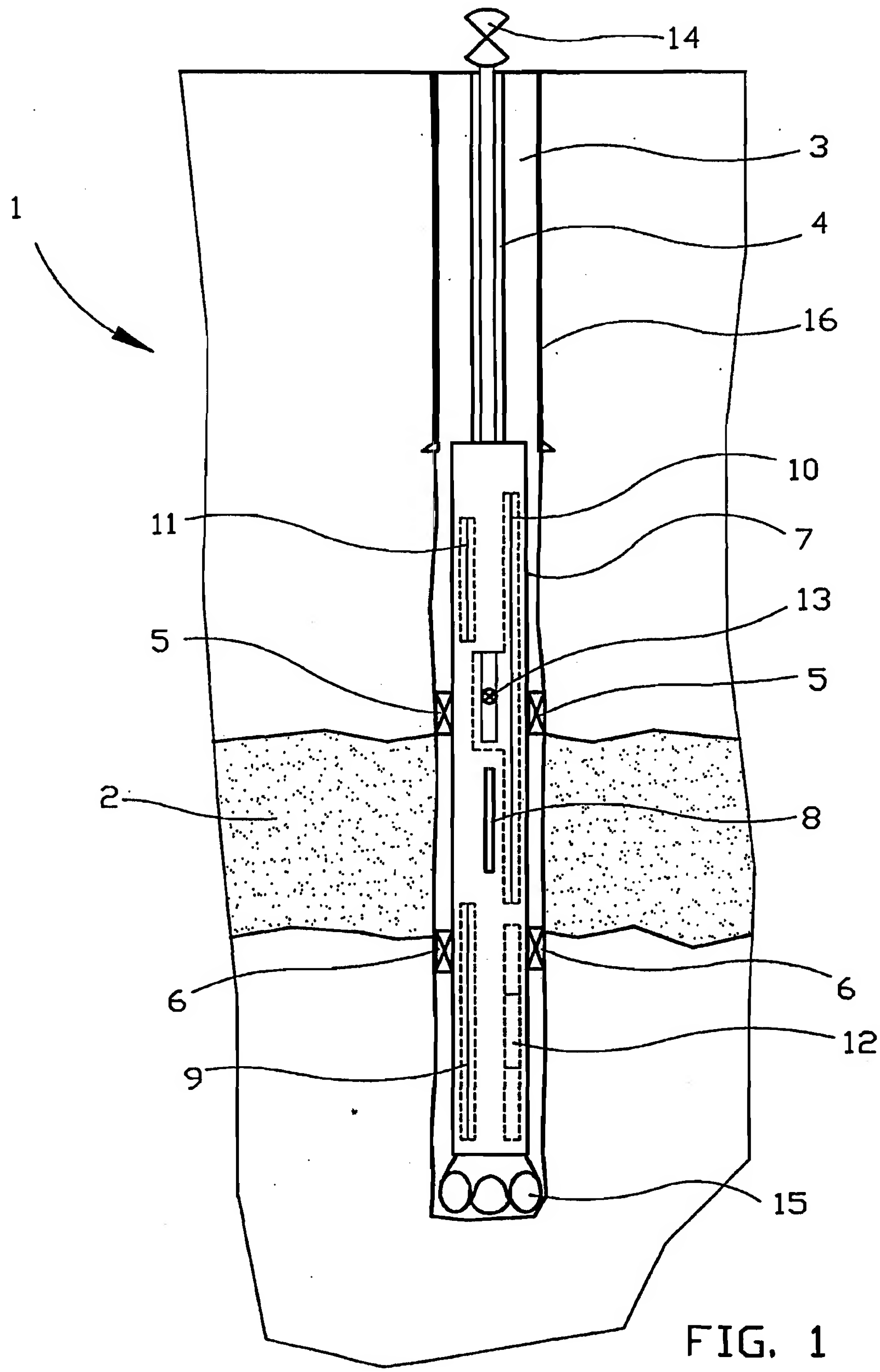

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 00/00020

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 49/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4535843 A (A.H. JAGELER), 20 August 1985 (20.08.85) --	1-12
A	US 5337821 A (G.L. PETERSON), 16 August 1994 (16.08.94) --	1-12
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A	US 5799733 A (P.D. RINGGENBERG ET AL), 1 Sept 1998 (01.09.98) --	1-12

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

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